FP

# Morris ARBORETUM BULLETIN

UNIVERSITY OF MICHIGAN
NOV 2 1961
LIBRARY

SEPTEMBER, 1961

VOL. 12 NUMBER 3

Science Library
QK
479
.P4
A3
V.12
NO.3

*Prunus Mume*

Published by
The ASSOCIATES of
THE MORRIS ARBORETUM

UNIVERSITY OF MICHIGAN LIBRARIES

THE MORRIS ARBORETUM OF THE UNIVERSITY OF PENNSYLVANIA

*Maintained by*
THE MORRIS FOUNDATION

ADVISORY BOARD OF MANAGERS
Gaylord P. Harnwell, *Chairman*

William M. David
Henry F. duPont
Maurice Bower Saul, *Counsel*
Charles J. Seltzer, Jr.
Wharton Sinkler
John W. Thorn

MEMBERS OF THE STAFF
John M. Fogg, Jr., *Director*

Patricia Allison, *Pathologist*
Hui-Lin Li, *Taxonomist*
Mary O. Milton, *Propagator*
John Tonkin, *Superintendent*
James O'Neil, *Custodian*
Fred W. Schwoebel, *Curator of the Langstroth Bee Garden*

The Morris Arboretum Bulletin is published quarterly at Philadelphia, Pa., by the Associates of the Morris Arboretum, Chestnut Hill, Philadelphia 18. Subscription, $1.50 for four issues. Single copies, 40 cents. Free to Associates.

THE ASSOCIATES, through whose interest and generosity *The Bulletin* and certain other undertakings of the Arboretum are made possible, is an informal group of individuals interested in encouraging and furthering the educational and research endeavors of the Morris Arboretum.

CLASSES OF MEMBERSHIP

Contributing .....$ 5.00 a year
Supporting .....$ 25.00 a year
Sustaining .....$10.00 a year
Sponsoring .....$100.00 a year
Donor.....$500.00

# Arboretum Activities

## THE STAFF

The Director attended the annual meetings of the American Association of Botanical Gardens and Arboretums which were held in Minneapolis on August 23 and 24. At the afternoon session of the first day he gave an illustrated talk on "The Registration of Cultivars in Magnolia."

Dr. Li has been awarded a Guggenheim Fellowship to further his studies on the Woody Plants of Formosa. He is spending six months at the University of California at Berkeley, where he is utilizing the herbarium resources of that institution in connection with this work.

Dr. Allison attended the meetings of the American Institute for Biological Sciences which took place at Purdue University, Lafayette, Indiana, from August 28 to September 1. Enroute she collected some fungus cultures and slime molds for research as well as general mycological material for class use.

## GIFTS TO THE LIBRARY

The Arboretum Library has recently received two small but valuable collections of books and periodicals.

*(Continued on Page 47)*

# Geographical Misnomers in Plants

HUI-LIN LI

In 1768, the British horticulturist Philip Miller in the eighth edition of his *Gardener's Dictionary*, described as *Xanthium chinense*, a cocklebur growing in London which he believed had originated in China. This was later found to be a mistake, and the original habitat was corrected to Vera Cruz, Mexico. In this case, fortunately, the misnomer was not continued in common usage, as it proved to be synonymous with the wide-spread *Xanthium strumarium* Linn.

Another New World plant bearing an Old World geographical name is *Canna indica* Linn., the Indian Shot. This name is still recognized and in general use. It is actually a plant of the West Indies and Central and South America, not of India, as Linnaeus indicated, although it is naturalized there. Still another is the common eastern American milkweed, which Linnaeus named *Asclepias syriaca*, supposing it to have come from the Orient.

Although such misnomers, in which New World plants bear Old World place names or vice versa, are relatively rare, there are numerous others with wrong geographical names. As a result the origin of the plants concerned is erroneously attributed to a different locality.

To the uninitiated a technical plant name in Latin is sometimes regarded as inscrutable and something to be avoided. Others believe the names represent absolute truth. Of course neither one of these points of view is entirely right. A botanical name is only a means and not an end in itself. That a certain number of these misnomers appear among the tens of thousands of names is no surprise to anyone familiar with the conditions and circumstances under which the system of naming plants has developed. The occurrence of these misnomers does not in any way debase our nomenclatural system. It is, however, imperative that there should be some understanding of these conditions for the effective use and appreciation of these technical names.

## BINOMIAL NOMENCLATURE

To begin with, a brief word about botanical names of species in general seems in order. The species is regarded as the basic unit of classification. Since each species bears a name consisting of two words, this system of naming plants is called binomial nomenclature. The first word is the name of a genus, in the form of a noun beginning with a capital letter. The second word is the specific epithet, generally in the form of an adjective conforming to the gender of the generic name. The author's name follows next and is often omitted in non-technical or general discourses. The specific epithet may be derived from sundry sources, such as a descriptive word, a personal name, a native plant name or a geographical place name. Here are some samples:

*Lonicera japonica* (Japanese Honey-suckle)
*Pinus nigra* (Black Pine)
*Rosa Banksiae* (Banks' Rose)

The technical name of a species can be roughly compared with the name of an individual, where the surname is equivalent to the generic name and the given name to the specific. The difference is that a botanical name is applied to a group of individuals of the same kind while a personal name is for one individual alone.

## PRINCIPLE OF PRIORITY

A plant species may sometimes receive more than one name from different botanists studying the same species independently. To avoid confusion and to provide essential stabilization to technical names, a set of rules has been developed and agreed upon by botanists at the international level to govern the creation, adoption and use of all plant names. Among the basic principles upon which these rules are formulated is the so-called law of priority, that is, the oldest or the first name given to a plant should be the one adopted. Other names of later origin pertaining to the same plant are treated as synonyms.

Botanists also agree among themselves that the adoption of binomials begins with Linnaeus, the father of modern taxonomy and the originator of the binomial system of nomenclature in current usage. Linnaeus's *Species Plantarum*, 1753, is the starting date of species names for flowering plants.

## GEOGRAPHICAL MISNOMERS

The advent of geographical misnomers is of course due to erroneous or confused notions about the original habitat of the plant concerned. This may be due to limited or incomplete information available to the author, but sometimes it may be due merely to his ignorance of geography. In any event, when a plant name is

Fig. 22. *Prunus tomentosa*

once proposed, and if it is the first name given to that plant species and established in accordance with all provisions of the rules of nomenclature, it is the name to be adopted. This includes also cases in which a geographical name may have been incorrectly applied.

At the time of Linnaeus many cultivated plants were already widely dispersed beyond their original range. Thus, when some of these plants received their first scientific names, they might not have been in their original habitat, a fact which sometimes may have escaped the notice of the author. This is the major source of geographical misnomers in plants.

## Misnomers by Linnaeus

More geographical misnomers appear in earlier taxonomic literature than in more recent works. This is to be expected as our geographical knowledge today is far more advanced and complete than that of our predecessors of the eighteenth and even the nineteenth centuries.

Linnaeus's *Species Plantarum* is actually a flora of the world, though an overly ambitious and premature one. He attempted to cover all parts of the world, Old as well as New, wherever he could obtain specimens either by himself or through his correspondents and students visiting and exploring distant countries. Among the plants he described are a number of familiar cultivated plants: *Salix babylonica* (Weeping Willow), *Prunus Armeniaca* (Apricot) and *Prunus Persica* (Peach), which Linnaeus believed had originated from Babylonia, Armenia and Persia respectively. These plants were later traced and found to be of Chinese origin, having been introduced into western Asia at earlier times. Although these names are not geographically appropriate, they are perpetuated because of the priority rule.

In describing his hundreds of species from many parts of the world, Linnaeus showed limited knowledge of eastern Asia. His records of India are mostly from the Malabar and Coromandel coasts of southern India, but may refer also to China. As a result he created a number of geographical misnomers which have ever since tended to confuse authors. These names are noted in some detail by Bretschneider (1898). More recently, Stearn (1957), in his introduction to a reprint of Linnaeus's *Species Plantarum*, says also, "Unfortunately Linnaeus seems to have confused China and India or regarded them as forming one region; he gave the epithet *indica* to Chinese species of *Daphne* and *Rosa* while recording them from China and the epithet *chinensis* to Chinese species of *Poa, Osbeckia, Dolichos*, etc. while recording them from India, as Bretschneider, (1898) pointed out."

A few of the more familiar plants under this category and still in current usage are: *Chrysanthemum indicum* Linn. (Garden Chrysanthemum), *Lagerstroemia indica* Linn. (Crape Myrtle), and *Rhododendron indicum* (Linn.) Sweet (based on *Azalea indica* Linn.). All these are plants of Chinese, not Indian, origin.

## Planta japonica

The largest group of geographical misnomers belong to plants bearing the name "japonica" or its equivalent. These plants cause among horticultural writers more confusion than any other groups, because they are among the more widely planted ones of the temperate gardens. While most of the plants named "japonica" are of Japanese origin, a number of them have their natural habitat in China. These plants are among the many cultivated plants introduced into Japan in the middle ages.

Fig. 23. *Eriobotyra japonica*

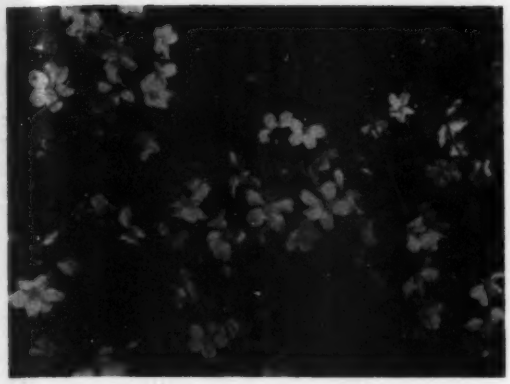

Fig. 24. *Kerria japonica*

In these early times, there were close contacts between China and Japan and from the former the latter imported through the centuries many intellectual refinements as well as amenities, from the written language and painting to medicine and tea-drinking. Many plants were introduced either for medicinal purposes or for ornamental usage. These plants, under long and intensive cultivation, often developed distinct garden forms in Japan and became very much an integral part of the Japanese cultivated flora.

During the seventeenth and eighteenth centuries, both China and Japan were closely guarded against foreign intrusion. The Dutch were the only Europeans who succeeded in maintaining a few trading establishments in some Japanese ports. Fortunately for science, the Dutch, unlike their immediate predecessors in the Far East, the Spaniards and Portuguese, had with them a few scholars versed in medicine and botany. These few, such as the Bavarian Philip Franz von Siebold and Carl Peter Thunberg (a Swede), bestowed upon us a legacy of botanical and horticultural information about the Far East in the eighteenth and in nineteenth centuries.

Most of the plants observed by these authors were from the gardens in and around the cities. When they first described these plants, they believed them all to be indigenous to the country. Actually, a large number of the garden plants in Japan are introductions from China in former times. Among the familiar garden plants of Chinese origin, but described first from plants cultivated in Japan, are: *Edgeworthia papyrifera* Sieb. & Zucc., *Daphne Genkwa* Sieb. & Zucc., *Daphne odora* Thunb., *Ginkgo biloba* Linn., *Hypericum patulum* Thunb., *Prunus Mume* Sieb. & Zucc. (cover), *Prunus tomentosa* Thunb. (Fig. 22), *Spiraea prunifolia* Sieb. & Succ., and many others.

From these early authors, as well as others later on we now have a very large list of Chinese plants bearing the label "japonica". Many of these names have since been relegated into the synonymy of other names and hence are not in current circulation. The following is an enumeration of those which are still in use. The authorities for the native habitat are Makino (1951). Nemoto (1936) and Rehder (1940).

(1) *Ampelopsis japonica* Thunb. Vitaceae.

Name based on *Vitis japonica* Thunb. This is a handsome woody vine with lustrous dark green finely cut foliage and pale yellow flowers in summer. It is a relatively tender plant and is thus not hardy in more northern temperate regions. According to Makino, it was introduced from China in the Kyo-ho era (1716-1736). The root of this plant is used in medicine, and this may have been the original reason of its introduction.

(2) *Anemone japonica* Sieb. & Zucc. Ranunculaceae

There is some confusion about the application of the correct name to this anemone. The name now generally accepted is *Anemone hupehensis*. A detailed account of the history of this plant is given by Bowles & Stearn (1947). The plant is considered native to central China.

(3) *Chaenomeles japonica* and *Cydonia japonica*. Rosaceae

The genus *Chaenomeles* was formerly included in *Cydonia* but the two are now generally treated as distinct. As a result, there is some overlapping and confusion in the names between the two. *Chaenomeles japonica* Lindl., based on the name *Pyrus japonica* Thunb., is a Japanese plant long cultivated in Japan. *Cydonia japonica* Pers., based on *Pyrus japonica* Sims not Thunb., however, is a Chinese plant of long standing in

Fig. 25. *Sophora japonica*

the garden there but was introduced into the Japanese garden in the middle ages. This is now treated as a synonym of *Chaenomeles lagenaria* (Loisel.) Koidz. but the name *Cydonia japonica* is still commonly used in garden literature. The common name of the plant is Japanese Quince.

(4) *Clematis japonica* (Houtt.) Makino. Ranunculaceae

According to Rehder and others, *Clematis japonica* Makino, based on *Anemone japonica* Houtt., is a different plant from *Clematis japonica* Thunb. The latter is a Japanese plant, but the former, accepted by Makino and Nemoto and treated as a synonym of *Clematis florida* Thunb. by Rehder, is a plant of Chinese origin that occurs in Japan only in the cultivated state.

(5) *Eriobotrya japonica* (Thunb.) Lindl. Rosaceae

Name based on *Mespilus japonica* Thunb. The Loquat is cultivated extensively in southeastern China and also in southern Japan. According to Rehder, its original habitat was in central China. (Fig. 23)

(6) *Gynura japonica* Makino. Compositae

This is a cultivated perennial with deep yellow flowers in autumn. According to Makino, it originated in China and was long ago introduced into Japan.

(7) *Fortunella japonica* Swingle. Rutaceae

The Kumquat was, as noted by Makino and many other authors, introduced into Japan from China in former times. It is the most handsome citrus tree, a dwarf much branched bush with many small bright orange fruits.

(8) *Isatis japonica* Miq. Cruciferae

According to Makino, who adopted the name *Isatis indigotica* Fortune, this plant originated in China and was introduced into Japan in the Kyo-ho era (1716-1736). In former times this was an important source of blue dye in China.

It is perhaps of some ethnological significance that species of this genus were used of old both in Europe and Asia as a dye plant. *Isatis tinctoria* Linn., of southeastern Europe, the Dyer's Woad, was used by ancient Europeans as a blue dye. Before indigo became common in Europe, the Dyer's Woad was the main source of blue dye for woolen material. According to Caesar, the Ancient Britons used the coloring matter to stain their bodies and the word Britain itself is derived from an old Celtic word meaning painted.

(9) *Kerria japonica* (Thunb.) DC. Rosaceae

The name was based on *Corchorus japonicus* Thunb. This familiar yellow-flowered shrub is widely cultivated in China and Japan and, according to Rehder, its original habitat is in central and western China. (Fig. 24).

(10) *Mahonia japonica* (Thunb.) DC. ....Berberidaceae

Based on *Ilex japonica* Thunb. This Mahonia is often confused with the commonly planted *Mahonia Bealii* (Fort.) Carr. It is a more tender plant and rare in western gardens. According to Makino, this species originated in China and was introduced into Japan in the Ten-na (1681-1684) and Jo-Kyo (1684-1688) eras.

(11) *Nepeta japonica* Maxim. Labiatae

This is an annual with whitish or pale pink flowers in summer. It is generally cultivated as a medicinal plant. According to Makino, it original habitat is in China.

(12) *Nothosmyrnium japonicum* Miq. Umbelliferae

This is a perennial with small white flowers in autumn. According to Makino, it was introduced into Japan in former times. Its cultivation in Japan is now generally limited to botanical gardens and most probably it was originally introduced as a medicinal plant.

(13) *Prunus japonica* Thunb. Rosaceae

This is a bushy plant not very commonly cultivated. Makino states that it is a plant of China, introduced into Japan. Rehder gives more precisely its original home as central China.

(14) *Serissa japonica* Thunb. Rubiaceae

This is a small evergreen shrub generally cultivated as a greenhouse plant. It produces small white or slightly pinkish flowers in early summer. Makino notes that it is cultivated in Japan.

(15) *Sophora japonica* Linn. Leguminosae

Makino notes that this is a tree of China, introduced into Japan in former times. Variously name as Chinese Scholar Tree or Japanese Pagoda Tree, this is one of the most cherished trees in China and its cultivation dates back to prehistoric times. (Fig. 25)

(16) *Stemona japonica* Miq. Stemonaceae

According to Makino, this plant appears in Japan only in gardens and was introduced from China in the Tokugawa period in the 17th century. This is a climbing perennial herb with a tuberous root. Apparently it was originally planted as a medicinal plant only.

BIBLIOGRAPHY


Bowles, C. A. and W. T. Stearn. The history of Anemone japonica. Journ. Roy. Hort. Soc. 72:261-268, 297-308. 1947.

Bretschneider, E. V. History of European Botanical Discoveries in China. 2 vols. 1898. London.

Makino, T. Illustrated Flora of Japan. Rev. ed. 1951. Tokyo.

Nemoto, K. Flora of Japan, Supplement. 1936. Tokyo.

Rehder, A. Manual of Cultivated Trees and Shrubs. Rev. ed. 1940. New York.

Stearn, W. T. Introduction to Linnaeus's Species Plantarum, a facsimile reprint of the first edition 1753. 1957. London.

# Our Seeds go Traveling

Mention has frequently been made in these pages of the manner in which botanical gardens and arboretums throughout the world offer collections of seeds to each other. In this connection, however, emphasis has generally been placed on the benefits which accrue to us as a result of this exchange.

It is therefore the purpose of this account to call attention to the contribution which the Morris Arboretum makes to the needs of other institutions in this country and abroad.

The collecting of seeds for our annual distribution may begin as early as May when some of the elms and maples mature their samaras. A few forms, such as *Elaeagnus multiflora,* ripen their fruit in midsummer. But the real harvesting of seeds begins in August and continues throughout September and much of October. During these months the task of collecting falls largely upon the shoulders of Miss Anne B. Clifford, Assistant Propagator, and Miss Elizabeth V. Orsatti, of the Records Department.

Great care must of course be taken to insure that seeds are taken only from plants of known identity as well as to avoid instances of open pollination which would introduce possibilities of hybridization.

Seeds which are borne in dry fruits, such as legumes, pods or capsules, are relatively easy to prepare for shipment. On the other hand, those which are enclosed in fleshy bodies such as berries, drupes or pomes must be carefully freed of pulp and dried, a procedure which may require considerable time.

By mid-November most of our seeds have been collected and processed and are ready for distribution. Then comes the task, usually allotted to Miss Orsatti, of arranging for mimeographing the list of available species arranged by families and genera.

Early in December the list is ready for distribution. It is sent out in duplicate (one copy to be checked and returned, the other to be retained by the recipient) with a covering letter.

In 1960 our seed list was mailed to 226 botanical gardens and arboretums. Of these 48 were domestic and 178 were foreign. Requests for seeds soon began to arrive and continued to come in during the Spring and early summer of 1961. In all, 113 institutions (18 domestic and 95 foreign) have asked for a total of 1386 species from our offerings.

There follows a list, alphabetically arranged by countries, of the botanical centers outside the United States from which orders were received:

Australia: Adelaide, Victoria.
Belgium: Boncelles, Brussesl, Kalmthout, Liège.
Brazil: Canoas.
Bulgaria: Sofia.
Canada: Montreal, Toronto (2), Vancouver.
China: Hong Kong.
Czechoslovakia: Bratislava, Brno (3), Prague, Slepcany.
Denmark: Copenhagen.
England: Kew, Wisley.
Estonia: Tartu.
Finland: Turku.
France: Haute-Garonne, Lyon, Paris, Rouen, Verrières-Le-Buisson.
Germany: Berlin-Dahlem, Bonne, Bremen, Darmstadt, Dortmund-Brunninghausen, Dresden, Eberswalde, Frankfurt, Greifswald, Hamburg, Kiel, Köln-Riehl, Mainz/Rhein, Munden, Munich, Potsdam-Sanssouci, Rostock.

Fig. 26. *Pseudolarix amabilis*

Holland: Delft, Leiden, Nijmegen, Utrecht, Wageningen (2).
Hungary: Budapest, Godollo, Sopron, Szeged, Utja, Vacratot.
Italy: Milan.
Japan: Kobe, Koshigaya-Machi, Kyoto.
Jugoslavia: Ljubljana.
Latvia: Dobele, Riga.
Malta: Floriana.
Poland: Bydgoszcz, Polska, Rogow Kolo Koluszek.
Portugal: Porto, Sacavem.
Roumania: Din Cluj.
Scotland: Auchincruive By Ayr, Edinburgh, Glasgow, St. Andrews.
Spain: Valencia.
Sweden: Lund, Stockholm, Uppsala.
Switzerland: Basel, De Neuchatel, Champex, Geneva.
USSR: Ashkhabad, Batumen, Kazachstan, Kiev, Leningrad (2), Lvov, Minsk, Moscow (2), Stalingrad.

As a matter of interest, Miss Orsatti has compiled a "Popularity Poll" of the species offered on our 1960 list. The "winner" was the Golden Larch, *Pseudolarix amabilis,* (Fig. 26) which was requested by 39 institutions. In second place was *Fagus grandifolia caroliniana,* with 35 requests. Third place was achieved by *Halesia diptera* (Fig. 27) with 33 "votes"; fourth by *Pinus Bungeana* (Fig. 28) with 31, and fifth by *Halesia monticola* with 30.

Here, in descending order, are listed those species for which fifteen or more requests were received:

23 requests:
Cornus Kousa
Ilex decidua
Pinus contorta
Rhododendron prunifolium

22 requests:
Acer palmatum
Aesculus parviflora
Cyrilla racemiflora
Davidia involucrata
Hamamelis intermedia

Fig. 27. *Halesia diptera*

Fig. 28. *Pinus Bungeana*

21 requests:
Halesia monticola vestita
Leucothoe editorum
Rhododendron serrulatum

20 requests:
Acer Buergerianum
Halesia carolina
Liriodendron Tulipifera
Oxydendrum arboreum
Pinus Griffithii
Pinus parviflora
Rhododendron viscosum montanum

19 requests:
Acer palmatum sanguineum
Cercis japonica
Hamamelis mollis
Ilex verticillata
Rhododendron alanticum
Rhododendron oblongifolium

18 requests:
Acer palmatum heptalobum

17 requests:
Actinidia arguta
Carpinus japonica
Hamamelis japonica flavo-purpurea
Pinus Peuce

16 requests:
Acer macrophyllum
Cercis canadensis
Rhododendron viscosum

15 requests:
Cedrus atlantica
Enkianthus perulatus
Styrax Obassia

J. M. F., Jr.

# Juvenile Variation in Five White Oak Species

FRANK S. SANTAMOUR, JR. AND
ERNST J. SCHREINER[1]

The Michaux Quercetum study is a joint project of the Morris Arboretum of the University of Pennsylvania and the Northeastern Forest Experiment Station of the Forest Service, U. S. Department of Agriculture, financed in part by the Michaux Fund of the American Philosophical Society. One of the objectives of this project, as outlined by Schramm and Schreiner (1954), is to provide information on the variation within oak species.

Several papers have already been published on the Quercetum. Acknowledgments to seed collectors and outlines and progress of early work were reported by Schramm and Schreiner (1954) and Li (1955). Gabriel (1958) described juvenile variation in Shumard oak, and Santamour (1960) reported on the seeding performance of oak species from the southern and western United States. This is a report on juvenile variation observed in five white oak species, *Q. alba, Prinus, stellata, macrocarpa* and *lyrata.*

## METHODS AND MATERIALS

The methods of seed collection and nursery practice have been treated in some detail by Schramm and Schreiner (1954) and Li (1955). However, for the sake of completeness and for the benefit of those readers who might not have ready access to these papers, the highlights are repeated here.

*Seed Collection and Shipment.* For each species or variety, collectors were asked to supply 100-125 acorns from each of two typical trees growing in natural woodlands in their locality. The parent trees were to be so situated that they received adequate cross-pollination from other trees of the same species. The seeds were placed in polyethylene bags and shipped to the Arboretum immediately after collection. The acorns were stored in a refrigerator for a few days before they were planted.

*Germination.* Germination counts for the seedlots fall-planted in 1953 began on April 23, 1954, and continued at 2- to 5-day intervals until June 1. After this date observations on germination were made at the same time the seedlings were measured for height growth. No special determinations of early germination rate were made on the seedlots planted in 1954, but germination data were available from the seedling counts when the height measurements were made.

*Nursery practice.* Special seedbeds were constructed for this study with 14-mesh, galvanized window screen at a soil depth of 9 inches.[2] The wire screen prevented the development of the long taproots characteristic of the oaks, and thus greatly facilitated lifting from the beds. Seedlings of tap-rooted species grown on wire also develop a branched root system and more fine lateral roots than seedlings grown without wire.

The acorns were fall-planted one-half inch deep and the soil was covered with one-half inch of sawdust. Planting was at the rate of 25 to a row (1953) or 20 to a row (1954) in rows 4 feet long and 6 inches apart. Each seedlot was replicated twice and the seedbeds were mouse-proofed until after germination. The seedlots were planted in order of receipt, with no special attention to grouping by species. The 1953 seed was planted on 11 different days between September 28 and November 5; the 1954 sowings were done on 17 different days between September 28, 1954, and January 3, 1955.

The seedlings sown in the fall of 1953 were transplanted to nursery rows in early April, 1955. All seedlings, dead or alive, were transplanted because it was impossible to recognize winter damage at this time. The 1954 seedlots were transplanted in early May, 1956, when live and dead trees could be separated more easily. Spacing in the transplant beds was 18 inches between seedlings in rows 3 feet apart. The seedlots were grouped by species in the transplant nursery and each seedlot was kept in the same replicate in which it occurred in the seedbed.

*Height Growth.* Measurements of first-year height growth were made at four periods, and individual seedlings were tallied in 2-centimeter height classes. It was impossible to measure all of the seedlots in a single day. Depending on the weather and other factors, the length of time required to measure all the seedlings ranged

[1] Geneticist and geneticist-in-charge respectively, Northeastern Forest Experiment Station, U. S. Forest Service. The forest genetics research is in cooperation with the Morris Arboretum of the University of Pennsylvania.

[2] E. J. Schreiner saw wired seedbeds in use at the Nut Tree Nurseries, Dowington, Pa., in the late 1920's. It is not known whether Mr. John W. Hershey, owner of the nursery, originated this method for growing tap-rooted species.

TABLE 1.—DATA ON QUERCUS ALBA AND Q. PRINUS

Table 1.—Data on Quercus alba and Q. prinus

| State | County | Elev. | Growing season | Seedlot number | Germination[1] | Average height 1-year | Average height 3-year | Autumn color ratings[2] 1 | Autumn color ratings[2] 2 | Autumn color ratings[2] 3 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Feet | Days | MQ– | Percent | Centimeters | Centimeters | Percent | Percent | Percent |
| **QUERCUS ALBA** | | | | | | | | | | |
| *1953 Fall sowing* | | | | | *6/1/54* | | | | | |
| Michigan | Cass | —— | 162 | 360 | 70 | 12.5 | 38.0 | 6 | 7 | 87 |
| Tennessee | Knox | 1000 | 217 | 213 | 90 | 19.5 | 51.8 | 26 | 48 | 26 |
| Texas | Montgomery | 200 | 260 | 012 | 57 | 24.5 | 71.9 | 100 | 0 | 0 |
| | " | | | 009 | 63 59 | 18.0 21.3 | 63.6 67.8 | 100 100 | 0 0 | 0 0 |
| *1954 Fall sowing* | | | | | *5/17/55* | | | | | |
| New Jersey | Somerset | 100 | 165 | 519 | 71 | 7.2 | 22.8 | 47 | 22 | 31 |
| | " | | | 520 | 92 86 | 10.7 8.5 | 22.4 22.6 | 6 21 | 7 13 | 87 66 |
| Pennsylvania | Northampton | 600 | 182 | 400 | 75 | 10.0 | 33.2 | 10 | 32 | 58 |
| | " | | | 442 | 93 83 | 9.8 9.9 | 27.4 30.3 | 3 6 | 22 27 | 75 67 |
| | Monroe | 1900 | 127 | 540 | 64 | 8.3 | 26.2 | 53 | 15 | 32 |
| Massachusetts | Middlesex | 300 | 162 | 174 | 89 | 10.0 | 28.5 | 9 | 48 | 43 |
| | " | | | 175 | 88 88 | 10.8 10.4 | 31.8 30.2 | 9 9 | 78 62 | 13 29 |
| Virginia | York | —— | 205 | 533 | 77 | 18.2 | 43.9 | 71 | 27 | 2 |
| | " | | | 535 | 50 62 | 7.8 13.0 | 29.3 36.6 | 85 78 | 14 20 | 2 2 |
| Maryland | Prince Georges | 200 | 178 | 575 | 88 | 14.5 | 35.1 | 20 | 73 | 7 |
| | " " | | | 577 | 70 79 | 11.3 12.9 | 27.4 31.3 | 23 22 | 71 72 | 6 6 |
| Maryland | Somerset | 50 | 181 | 032 | 100 | 14.2 | 43.0 | 25 | 50 | 25 |
| | Talbot | 25 | 195 | 034 | 75 | 9.8 | 32.4 | 18 | 27 | 55 |
| Arkansas | Stone | 1000 | 215 | 263 | 100 | 10.2 | 36.8 | 12 | 15 | 73 |
| | " | | | 267 | 100 100 | 10.9 10.6 | 27.8 32.3 | 0 8 | 9 13 | 91 79 |
| Illinois | Hardin | 500 | 192 | 463 | 100 | 12.4 | 28.2 | 13 | 13 | 74 |
| North Carolina | Buncombe | 2200 | 194 | 662 | 94 | 8.8 | 20.8 | 0 | 15 | 85 |
| **QUERCUS PRINUS** | | | | | | | | | | |
| *1953 Fall sowing* | | | | | *6/1/54* | | | | | |
| Ohio | Ashland | —— | 157 | 352 | 77 | 20.1 | 72.1 | 4 | 59 | 37 |
| | " | | | 353 | 65 74 | 15.0 17.6 | 54.2 63.2 | 20 8 | 67 60 | 13 32 |
| Virginia | Montgomery | 2100 | 168 | 109 | 97 | 23.9 | 68.5 | 3 | 86 | 11 |
| *1954 Fall sowing* | | | | | *5/17/55* | | | | | |
| Massachusetts | Worcester | 875 | 153 | 173 | 100 | 15.0 | 36.2 | 38 | 62 | 0 |
| Connecticut | New Haven | 75 | 195 | 189 | 100 | 16.8 | 38.9 | 48 | 38 | 14 |
| | " " | | | 190 | 100 100 | 18.6 17.7 | 52.7 45.8 | 12 32 | 88 60 | 0 8 |
| New Jersey | Camden | 100 | 194 | 594 | 100 | 21.3 | 43.8 | 11 | 83 | 6 |
| Pennsylvania | Monroe | 720 | 127 | 443 | 100 | 18.2 | 39.4 | 5 | 46 | 49 |
| | " | | | 444 | 97 98 | 16.8 17.5 | 37.1 38.3 | 6 6 | 48 47 | 46 47 |
| | " | 1900 | 127 | 539 | 100 | 14.6 | 42.7 | 75 | 21 | 4 |
| | " | | | 541 | 100 100 | 18.3 16.5 | 51.1 46.9 | 14 28 | 48 41 | 38 31 |
| Maryland | Prince Georges | 250 | 178 | 578 | 100 | 21.9 | 52.8 | 10 | 89 | 1 |
| | " " | | | 579 | 100 100 | 23.8 22.9 | 45.1 49.0 | 7 8 | 88 89 | 5 3 |
| Ohio | Vinton | —— | 149 | 458 | 97 | 16.8 | 50.9 | 17 | 59 | 24 |
| | " | | | 459 | 97 97 | 16.9 16.9 | 62.2 56.6 | 3 7 | 48 51 | 49 42 |
| South Carolina | Berkeley | 30 | 265 | 430 | 100 | 13.9 | 37.4 | 43 | 57 | 0 |

[1]Percent of total germination on the dates indicated.

[2]1 = green; 2 = red-, orange-, or yellow-green; 3 = red, brown, or fallen.

from 4 days to 2 weeks. However, measurements were made in the same sequence for each period, and when practical, all seedlings in a seedbed were measured on the same day. In 1954 the seedlings were measured in early June, mid-July, and late August; the final growth measurement for the 1-year-old trees in the seedbeds was made during the dormant season in February and March of 1955. The seedlots germinating in 1955 were measured in mid-May, early July, early August, and early November.

The percent of total first-year height attained

at each of the intermediate measurement periods was greatly confounded with germination rate. In one seedlot: August germination of a small number of seedlings reduced the average height to a figure below that of the July measurement. For this reason the variation in first-year growth pattern has not been included in this report.

Second- and third-year height measurements of the 1953 seedlots were made after growth had ceased in late fall. Lack of personnel prevented second-year measurement of the 1954 seedlots in the fall of 1956 and practically 100 percent of the trees were cut almost to ground level by rabbits during the winter of 1956-57. These seedlots were measured in the fall of 1957; the 3-year height therefore represents the re-growth of these trees following severe rabbit damage. All of these measurements were made in quarter-foot height classes.

Data on acorn weight were taken but unfortunately cannot now be located in the Michaux Quercetum files. There have been reports that acorn weight is correlated with juvenile height growth (Johnsson, 1952; among others). But we have seen no conclusive evidence regarding the extent to which seed weight in the oaks is under genetic control; to what extent it is the direct expression of the inherent vigor of the parent tree, or possibly the effect of xenia or metaxenia. It is possible that in this study height comparisons are confounded with differences in acorn weight.

*Mortality.* Seedling mortality for all seedlots was checked at the beginning of the second growing season, the end of the second year, and the end of the third year.

As noted above, transplanting of the 1953 seedlots was done at a time when the dead seedlings could not be distinguished. Thus the mortality observed after the trees had leafed out was a combination of winter-killing and transplanting losses. Li (1955) has pointed out that seedlings from the colder climatic regions averaged about five percent mortality after transplanting. Although there may be differences in transplantability between species, any mortality above five percent may possibly be interpreted as due to winter injury.

The seedbed area was fenced against rabbits and there was also no rabbit damage of any consequence to the 1953 seedlots in the transplant nursery. As noted previously, when the 1954 seedlots were 2-years-old, (winter of 1956-57) all of these seedlings were bitten off between ground level and a 3-inch stump. Mortality recorded after the trees had sprouted may therefore be a measure of the ability to recover from injury rather than inherent susceptibility to climatic conditions. Because of the extent and variability of the rabbit damage no attempt has been made to analyze 3-year survival of these seedlots for possible genetic differences between sources.

Data on stem dieback of the 1953 seedlots during the first winter were taken after transplanting in June, 1955. Because of the possible confounding of winter injury with transplanting damage no valid analyses for genetic differences could be made. The only information on first-year dieback of the 1954 seedlots was taken in November, 1955. At this time only the non-hardy species from the South and West had suffered damage from early frosts.

*Autumn Leaf Color.* Fall leaf color was recorded for each seedling between November 4 and 11, 1955. At this time the 1953 seedlings were two years old and the 1954 seedlings had just completed their first growing season. In order to increase the objectivity of these observations, all seedlings of a given replicate were scored by the same observer on the same day. Conclusions on unusual differences were checked by another observer.

There is some question as to whether fall-color determinations made on 1- and 2-year-old seedlings are directly comparable. In some species the first-year seedlings tended to lose their green color less rapidly than the older seedlings from similar areas. In other species, there appeared to be very little difference. For these reasons comparisons and conclusions regarding fall leaf color have been based on seedlings of the same age.

*Analysis of the Data.* The analysis of variance was used to determine differences between seedlots and localities for germination rate and height when there were more than 5 seedlots planted in a given year. With a smaller number of seedlots, comparisons were made using the *t*-test. For autumn leaf color, the departure from the average of all seedlots of a species planted in the same year was determined by chi-square tests. Additional analyses such as the correlation analysis and Keul's sequential sampling technique were used as mentioned in the text.

## Discussion of Results

### *QUERCUS ALBA*

*Germination.* Of the acorns sown in the fall of 1953 the Texas seedlots were the slowest to germinate; 59 percent of their total germination on June 1 as compared to 90 percent for the Tennessee lot (table 1). For the 1954 seedlots the percent of total germination on May 17, 1955, varied from 50 to 100 percent. The differ-

TABLE 2.—DATA ON QUERCUS STELLATA, Q. MACROCARPA AND Q. LYRATA

Table 2.—Data on Quercus stellata, Q. macrocarpa and Q. lyrata

| State | County | Elev. | Growing season | Seedlot number | Germination[1] | Average height 1-year | | Average height 3-year | | Autumn color ratings[2] 1 | | Autumn color ratings[2] 2 | | Autumn color ratings[2] 3 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Feet | Days | MQ- | Percent | Centimeters | | Centimeters | | Percent | | Percent | | Percent | |
| **QUERCUS STELLATA** | | | | | | | | | | | | | | | |
| *1953 Fall sowing* | | | | | *6/1/54* | | | | | | | | | | |
| Illinois | Cumberland | — | 173 | 419 | 77 | 10.2 | | 32.5 | | 15 | | 33 | | 42 | |
| | " | | | 423 | 81 | 78 | 9.7 | 10.0 | 31.0 | 31.8 | 6 | 12 | 28 | 31 | 66 | 57 |
| Tennessee | Bledsoe | — | 197 | 229 | 71 | | 15.7 | | 38.6 | | 6 | | 29 | | 65 | |
| | " | | | 230 | 57 | 63 | 10.3 | 13.0 | 40.6 | 39.6 | 3 | 4 | 53 | 43 | 44 | 53 |
| Arkansas | Boone | 1200 | 187 | 261 | | 0 | | 5.6 | | — | | 0 | | 100[4] | | 0 |
| | Ashley | 180 | 227 | 296 | | 16 | | 7.6 | | 37.6 | | 30 | | 50 | | 5 |
| Florida[3] | Putnam | 75 | 314 | 335 | | 10 | | 9.7 | | 35.1 | | 24 | | 48 | | 4 |
| *1954 Fall sowing* | | | | | *5/17/55* | | | | | | | | | | |
| Missouri | Dent | 1260 | 182 | 474 | 32 | | 6.7 | | 25.9 | | 56 | | 34 | | 10 | |
| | " | | | 475 | 22 | 27 | 9.3 | 8.0 | 35.4 | 30.7 | 47 | 52 | 53 | 43 | 0 | 5 |
| Maryland | Prince Georges | 175 | 178 | 580 | 56 | | 11.7 | | 27.5 | | 13 | | 68 | | 19 | |
| | " " | | | 581 | 65 | 58 | 12.4 | 12.1 | 35.5 | 31.5 | 22 | 18 | 78 | 74 | 0 | 8 |
| Connecticut | New Haven | 100 | 195 | 187 | | 68 | | 9.8 | | 25.5 | | 27 | | 73 | | 0 |
| **QUERCUS MACROCARPA** | | | | | | | | | | | | | | | |
| *1953 Fall sowing* | | | | | *5/7/54* | | | | | | | | | | |
| South Dakota | Brookings | 1700 | 136 | 185 | 67 | | 13.5 | | 62.9 | | 6 | | 17 | | 77 | |
| | " | | | 186 | 69 | 68 | 14.9 | 14.2 | 67.3 | 65.1 | 3 | 5 | 3 | 9 | 94 | 86 |
| Kansas | Pottawatomie | 1000 | 183 | 053 | | 0 | | 23.2 | | 92.8 | | 25 | | 19 | | 56 |
| | Riley | 1000 | 171 | 402 | | 0 | | 19.2 | | 108.0 | | 4 | | 40 | | 56 |
| *1954 Fall sowing* | | | | | *5/17/55* | | | | | | | | | | |
| Minnesota | Itasca | 1300 | 111 | 354 | 84 | | 11.6 | | 44.2 | | 0 | | 6 | | 94 | |
| | " | | | 355 | 79 | 82 | 10.2 | 10.7 | 42.2 | 43.2 | 11 | 5 | 12 | 9 | 77 | 86 |
| Illinois | —— | —— | — | 543 | | 27 | | 25.0 | | 83.3 | | 64 | | 36 | | 0 |
| **QUERCUS LYRATA** | | | | | | | | | | | | | | | |
| *1953 Fall sowing* | | | | | *6/1/54* | | | | | | | | | | |
| Mississippi | Tallahatchie | 135 | 210 | 282 | 24 | | 26.0 | | 78.0 | | 27 | | 71 | | 2 | |
| | " | | | 283 | 25 | 24 | 33.6 | 29.8 | 88 9 | 83.5 | 51 | 37 | 49 | 62 | 0 | 1 |
| Arkansas | Ashley | 180 | 227 | 295 | | 85 | | 29.9 | | 84.5 | | 26 | | 61 | | 13 |
| Texas | Houston | 150 | 252 | 015 | | 54 | | 35.1 | | 78.3 | | 49 | | 51 | | 0 |

[1]Percent of total germination on the indicated dates
[2]1 = green; 2 = red-, orange-, or yellow-green; 3 = red, brown, or fallen
[3]*Q. stellata* var. *margaretta*
[4]Only 2 living trees

ences between seedlots were not statistically significant in either year because of random unaccountable variation.

*Height Growth.* For the 1953 fall sowing there was no significant correlation between first- and third-year heights and the analysis of variance failed to show any significant difference between seedlots for height in either year. For a more sensitive test of the differences between seedlots the average heights were compared by *t*-tests. The Michigan seedlot was significantly less vigorous than either the Tennessee or Texas progenies. Although the average height of the two Texas progenies was significantly greater than that of the Tennessee seedlot, one of the Texas progenies (009) did not differ significantly in height growth from the Tennessee seedlings. The two Texas seedlots were not significantly different. (Fig. 29).

The correlation between 1-year and 3-year heights was highly significant ($r = +0.740$) for the 1954 sowing. Although the correlation only accounts for approximately 54 percent of the variation associated with the correlated changes in 1-year and 3-year heights, 3-year height is apparently a fair measure of growth vigor in spite of the severe rabbit damage during the second winter.

There was no correlation between 3-year height and length of growing season of the parent-tree locality. Although there were no

Table 3. — *Quercus alba. Comparison of average three-year height growth*

*Studentized range test*[1]

| State | County | Seedlot number | Average height |
|---|---|---|---|
| | | *MQ–* | *Cm.* |
| North Carolina | Bumcombe | 662 | 20.8 |
| New Jersey | Somerset | 520 | 22.4 |
| New Jersey | Somerset | 519 | 22.8 |
| Pennsylvania | Monroe | 540 | 26.2 |
| Pennsylvania | Northampton | 442 | 27.4 |
| Maryland | Prince Georges | 577 | 27.4 |
| Arkansas | Stone | 267 | 27.8 |
| Illinois | Hardin | 463 | 28.2 |
| Massachusetts | Middlesex | 174 | 28.5 |
| Virginia | York | 535 | 29.3 |
| Massachusetts | Middlesex | 175 | 31.8 |
| Maryland | Talbot | 034 | 32.4 |
| Pennsylvania | Northampton | 400 | 33.2 |
| Maryland | Prince Georges | 575 | 35.1 |
| Arkansas | Stone | 263 | 36.8 |
| Maryland | Somerset | 032 | 43.0 |
| Virginia | York | 533 | 43.9 |

[1] Brackets inclose means that are not significantly different at the 5 percent level.

statistically significant differences between the average 1-year or 3-year heights based on locality of the parent trees, there were highly significant height differences between seedlots for both years.

The seedlot means compared by the Studentized range test (Keuls, 1952) fall in four widely overlapping groups (table 3). Such grouping would indicate that the variation is not discontinuous, and since there is no geographic trend (either north-south or east-west) there is also no sound basis for postulating clinal variation. However, the data do provide evidence for probable local ecotypic differences and for significant individual variation within localities. The differences between the average 3-year heights of the two seedlots from Northampton County, Penna., Prince Georges County, Md., and York County, Va., were significant at the one percent level (*t-test*); the difference between the Arkansas seedlots was not significant.

*Three-year survival.* Survival of the individual seedlots at the end of three years varied from 50 to 89 percent and between localities from 58 to 85 percent. For the reasons noted previously the data do not provide evidence of genetic differences between the provenances that favor three-year survival in the Philadelphia area.

*Autumn Coloration.* On the basis of chi-square tests the autumn coloration of the seedlings from the following localities were signficantly different at the one percent level from the average for the respective years: Michigan; Texas; New Jersey; Northampton County, Pennsylvania; Massachusetts; Virginia; and Prince Georges County, Maryland.

An inherent potential for southern provenances to hold their green color late in the fall might be inferred from the data in table 1 for the Texas, Tennessee, and Michigan seedlots sown in the fall of 1953. The seedlots sown in the fall of 1954 do not show this clear-cut latitudinal variation. Although there is a tendency for southern origins to maintain green color later in the fall than northern seedlots, this latitudinal picture has several marked exceptions.

The North Carolina source is southern but none of these trees maintained completely green color (rating class 1); 85 percent of the trees in this progeny were red, brown or shed. The elevation of the parent trees of this seedlot is 2200

Fig. 29. *Q. alba* (MQ-009) from Texas appears to thrive under Philadelphia conditions.

feet. The Arkansas progenies from parent trees at an elevation of 1000 feet also had few green individuals (8 percent). The Pennsylvania progenies from Northampton ounty had 6 percent green trees and the Monroe County progeny had 53 percent. These two seedlots differ by thirteen hundred feet in the elevation of the parent trees. The percent of green trees was reasonably uniform in the Maryland provenances, but there was wide variation (27 percent to 72 percent) in trees rated 2. In this case there is little difference in elevation and in length of the growing season of the parent-tree locality.

There was also a wide range within localities (individual variation) in all rating classes. For rating class 1, for example, the values for the two progenies from New Jersey are 6 and 47 percent, the Pennsylvania progenies from Northampton County varied from 3 to 10 percent and the progenies from Stone County, Arkansas, varied from 0 to 12 percent.

The results of this study do not warrant the generalization that in the Philadelphia area autumn leaf coloration is later in progenies from southern parents than from northern origins. Such latitudinal correlation is indicated by the four 1953 seedlots, possibly because they represent continental provenances, but the 1954 seedlots, including maritime and continental provenances, depart drastically from this pattern.

The 21 progenies of *Q. alba* grown under the conditions of this study for three years have demonstrated wide genetic variation between the progenies of parent trees from the same locality. There is some indication of possible north-south variation between continental provenances, but the number of such provenances sampled is too small to be conclusive or to indicate whether such variation is continuous or discontinuous. The results also favor the conclusion that in this species genetic variation represents local ecotypes rather than clinal or racial differences.

### *Q. PRINUS*

Data on this species are presented in table 1. The difference in percent of total germination between the 1953 fall-sown seedlots from Ohio (74 percent) and Virginia (97 percent) was significant at the one percent level. There were no significant differences in earliness of germination between seedlots (range 97 percent to 100 percent) for the 1954 fall sowing.

The difference in 1-year and 3-year height between the average of the two Ohio seedlots and the Virginia seedlots planted in 1953 was not significant. Although the Virginia seedlot was

Fig. 30. *Q. lyrata* (MQ-283) The dense, compact crown of young trees is quite distinct.

Fig. 31. *Q. macrocarpa* (MQ-409) from Kansas, 9 feet tall, has maintained its superiority over the South Dakota progenies.

significantly taller than Ohio 353 in both years, it was not significantly better than Ohio 352. The differences among the 1954 seedlots in 1-year height were signficant but the differences between localities were not significant. The differences in 3-year height were large but not significant for either seedlots or localities because of wide random fluctuations; it is apparent from the table that the differences within localities are nearly as large as those between localities. Since the correlation between 1-year and 3-year height was not significant it is possible that the rabbit damage in the second winter may be responsible for the lack of significant differences in 3-year height. (Fig. 33).

The difference between localities in 3-year survival of the 1953 seedlots (Ohio 74 percent, Virginia 92 percent) was significant at the one percent level. For the 1954 sowing, three-year survival ranged from 48 percent to 100 percent. The confounding of survival with severe rabbit damage makes it impossible to estimate the importance of genetic differences responsible for the variation in survival between seedlots and localities.

For the 1953 sowing there was no significant departure from the averages in each of the 3 autumn color groups. Among the 1954 seedlots only the progenies from the low elevation provenance in Monroe County, Pa. and from Prince Georges County, Md., were significantly different from the average. The two seedlots from each of these localities were quite similar but in the other localities represented by two seedlots there were marked differences between the progenies, indicating considerable individual variation. In this species there appeared to be no association of fall color with origin, especially since the most northerly and the most southerly locations had the highest percentages of trees with green or red-green leaves.

On the basis of these data variation in *Q. Prinus* appears to result primarily from genetic differences between the parent trees. Racial or ecotypic variation is not apparent from this limited study.

## *Q. STELLATA*

All of the collections of post oak planted in 1953 were typical of the species except the collection from Florida which was *Q. stellata* var. *Margaretta* (Ashe) Sarg., the sand post oak (table 2).

Fig. 32. *Q. macrocarpa* (MQ-186) from South Dakota; specimens from this state are only 4 to 5 feet tall and appear more susceptible to insect damage.

For the 1953 sowing, the difference between seedlots and between localities in earliness of germination was highly significant. The Illinois and Tennessee seedlots began to germinate during the first week in May. The seed from Boone County, Arkansas, did not germinate until the first week in July and the total germination percent was quite low (6 percent). The percent of total germination on June 1, 1954, varied from 0 to 81 percent between seedlots, and from 0 to 78 percent between seed collection localities.

The five seedlots planted in 1954 also showed significant differences in percent germination on May 17, 1955. Between seedlots the range was from 22 percent to 68 percent, and between localities from 27 percent to 68 percent. Although the trend in both years was for earlier germination of seed from northern than from southern provenances, there was wide variation between the Boone County, Arkansas, progeny from 1200 feet elevation and the Ashley County, Arkansas, seedlot from 180 feet elevation.

For both the 1953 and the 1954 sowings, there were no significant differences between seedlots or localities in 1-year height or 3-year height.

The difference in survival between the 1953 seedlots (ranging from 0 to 78 percent) was significant. The late-germinating Boone County, Arkansas, source had completely disappeared by the end of the third year. For the 1954 progenies, survival following transplanting and rabbit damage was 62 percent for the Maryland source, 36 percent for Missouri, and 5 percent for Connecticut. Since it was not possible to determine to what degree each of these two factors was responsible for mortality there is no basis for estimating the importance of genetic differences as a factor responsible for survival.

There were significant differences between localities in autumn leaf color of the 1953 progenies. Only 43 percent of the Illinois seedlings and 47 percent of those from Tennessee showed some green in their leaves (rating 1 and 2) whereas 80 percent of the Ashley County, Arkansas, seedlings and 72 percent of the Florida plants still showed some green leaf color. There was also considerable variation between progenies from the same locality in several of the rating classes. In the 1954 seedlots, 92 percent or more of the seedlings from each of the three localities had green or red-green leaves (ratings 1 and 2). But there was greater variation in rating class 1; 52 percent of the Missouri, 18 percent of the Maryland, and 27 percent of the Connecticut seedlings had green leaves.

Although only eight different provenances were tested, there was a trend for earlier germination and earlier autumn coloration in northern seedlots. This may indicate clinal or racial differences in these characters. However, there were no significant differences in 1-year and 3-year heights. For the progenies tested, this character was more uniform in this species, both between and within localities, than in the other white oaks represented by as wide a sampling range.

Fig. 33. *Q. Prinus* (MQ-109) from Virginia is quite vigorous and free from insect attack.

## *Q. MACROCARPA*

Two seedlots each from South Dakota and Kansas were planted in 1953. The climate in the areas of origin of these seedlots is so different that considerable variation might be expected. The 1954 sowing included two seedlots from Minnesota, and one seedlot from Illinois.

The South Dakota seedlings began to germinate on April 26, 1954, and by May 7, 68 percent of the final total had germinated (Table 2). The Kansas seedlots did not start germination until May 11. The Illinois acorns were slower to germinate than those from Minnesota; only 27 percent of the total had germinated by May 16, 1955, in contrast to 82 percent for the Minnesota source.

The height growth of the Kansas seedlings was significantly better than that of the South Dakota seedlot at the end of both the first year

(21 cm. vs. 14 cm.), and the third year (100 cm. vs. 65 cm.) in the nursery. The Illinois seedlings were taller than those from Minnesota at the end of the first year (25 cm. vs. 11 cm.) and after sprouting in 1957 (83 cm. vs. 43 cm.). The difference between these provenances was not significant because of the large variation between the Illinois replicates. (Figs. 31 & 32).

There were no significant differences in 3-year survival between seedlots planted in the same year. Survival of the 1953 seedlots was 93 percent to 100 percent; for the 1954 seedlots it was 78 percent to 88 percent.

The differences in fall leaf color for both years of sowing were highly significant. Forty-four percent of the Kansas seedlings had green or red-green leaves at the time of observation while only 14 percent of the South Dakota seedlings showed any green in their leaves. Although there was considerable difference between the two Kansas seedlots in the percentage of trees with green leaves, they did not differ in the percentage of trees showing some green color (ratings 1 and 2). All of the Illinois seedlings showed some green in their leaves (ratings 1 and 2), but only 14 percent of the Minnesota seedlings had green or red-green leaves.

The seedlots of this species, all from localities with continental climates, show the same pattern of north-south variation in earliness of germination, lower 1-year and 3-year height growth, and earlier fall coloration. The number of provenances is obviously too small to indicate whether these variations are clinal or discontinuous, or whether they indicate racial or local ecotypic differences.

### *Q. LYRATA*

Although the range of *Q. lyrata* extends as far north as New Jersey and Delaware, the only collections in the Quercetum were from Mississippi, Arkansas, and Texas. All of these seedlots were remarkably similar in the characteristics studied with the exception of germination rate (table 2).

Percent of total germination on June 1 was 24 percent for Mississippi, 85 percent for Arkansas, and 54 percent for Texas. Since the latitudinal and climatic range of these seedlots was small the variation in germination rate may have been due to unknown internal and external environmental factors or possibly to local ecotypic variation. (Fig. 30).

Three-year survival between localities (71 to 89 percent) was not significant because of the wide difference between the two progenies from Mississippi (69 percent vs. 95 percent). Differences between 1-year and 3-year heights were also not significant and the progenies from the three localities did not differ from the average in autumn coloration.

The data on height growth, 3-year-survival, and autumn coloration may indicate individual variation between the two parent trees from Mississippi but the data did not provide evidence of genetic differences between localities.

### Summary and Conclusions

This report covers a study of variation observed during 3 growing seasons between 21 single-tree progenies of *Q. alba*, 16 of *Q. prinus*, 12 of *Q. stellata*, 7 of *Q. macrocarpa*, and 4 of *Q. lyrata*. The seedlings were grown for one year in seedbeds and two years in a transplant nursery at the Morris Arboretum, Philadelphia, Pennsylvania.

The variables available for progeny comparisons were earliness of germination, 1-year and 3-year height growth, and autumn coloration. On the basis of these three variables, and with due consideration of the exploratory nature of this study and the limited sampling of the species, the authors offer the following conclusions:

1. In *Quercus alba* there was wide variation between progenies of individual trees. Although there was some indication of north-south variation between continental provenances, the results favored the conclusion that genetic variation represents local ecotypes rather than clinal or racial differences.

2. Racial or ecotypic variation was not apparent in *Q. prinus* from this limited study. There were differences between the progenies of individual parent trees.

3. There was a trend in *Q. stellata* for earlier germination and earlier autumn coloration in northern seedlots. Height growth of the progenies tested was more uniform in this species than in the other white oaks represented by as wide a sampling range.

4. The 7 seedlots of *Q. macrocarpa* from 4 continental localities showed a pattern of north-south variation.

5. The four seedlots of *Q. lyrata* from within a relatively small geographic area did not provide evidence of genetic differences between localities.

6. This study has shown the necessity for maintaining the identities of individual parent-tree progenies in provenance tests of these white oak species.

7. For genetic improvement in these species individual tree selection appears to offer more promise than ecotypic or racial selection.

### Acknowledgements

The Michaux Quercetum has been a truly cooperative project since its inception. Personnel of the Morris Arboretum of the University of Pennsylvania, originally supervised by former director, J. R. Schramm, and now under the direction of John M. Fogg, Jr., have been responsible for nearly all the contacts with seed collectors and most of the nursery work. H. L. Li and Mary O. Milton have handled the accession records and herbarium specimens.

The measurement and evaluation phases of the project have been handled by the genetics personnel of the Northeastern Forest Experiment Station, U. S. Forst Service.


### Literature Cited


Gabriel, William J. 1958. Genetic differences in juvenile Shumard oak. Northeastern Forest Experiment Station Research Note No. 81, 3 pp.

Johnsson, H. 1952. Ungdomsutvecklingen hos Stjälkek, druvek och rödek. Svensk. Skogsvardsf. Tidskr. No. 2. pp. 168-193.

Keuls, M. 1952. The use of the "Studentized range" in connection with an analysis of variance. Euphytica *1:* 112-122.

Li. Hui-Lin. 1955. A progress report on the Michaux Quercetum. Morris Arboretum Bulletin *6:* 45-47.

Santamour, Frank S. Jr. 1960. Western and southern oaks in the Michaux Quercetum. Morris Arboretum Bulletin *11:* 7-10.

Schramm, J. R. and Schreiner, Ernst J. 1954. The Michaux Quercetum. Morris Arboretum Bulletin *5:* 54-57.


# Associates' Corner

## The Climatron

As Arboretumites we are naturally interested in what the other fellow is doing, so hearing much of the new idea of a greenhouse constructed by the Missouri Botanical Garden in St. Louis, your chairman packed up the trusty station wagon and went to investigate. It was well worth the trip.

The building is called a Climatron because it is constructed to emphasize climate-control facilities. It is a geodesic dome made of aluminum tubing arranged in hexagonal patterns and lined with a layer of ¼ inch thick Plexiglass, 70 feet high and covers a little over ¾ of an acre. It is equipped with two automatic independent air circulation systems, with temperature, humidity and volume of air controlled by elaborate pneumatic switches and motors operating fans, dampers and water spray nozzles, so controlled they permit several different climates in separate parts of the building, from an Amazonian forest and bog area, an underwater tunnel (you don't need a snorkel to see the roots of the aquatic plants) to a tropical mountain forest and even an oceanic climate.

A gallery runs around the upper part of the building from which one can view the over-all, and leads down to the lower level where one can wander along paths and inspect the individual plants at close range. Loud speakers send forth the different cries of the tropical birds supposedly inhabiting this fantastic abode. They add to the atmosphere, but I missed the Howler Monkeys. Perhaps they thought the humans could make up for that noise.

Scattered through these forests are artificial trees made of steel pipes welded together and covered with black Osmunda fiber, an excellent substitute for tree bark, on which hundreds of orchids grew, many of them in flower.

Being drug conscious and proud of our own garden, I was interested to see *Strophanthus gratus* in their collection. Another intriguing plant was the Telegraph Plant (*Desmodium gyrans*) a member of the pea family, whose leaflets are in constant motion becoming more animated as the motion mounts. They seem to be signalling to each other; hence the layman's name for them. No one knows why or how they move. Here is a chance for one of us amateur botanists to discover the secret.

An amusing touch was a machine just under a group of Macadamia nut trees, containing the nuts. By placing a nickle in this machine you could get a nut and sample the taste for yourself.

The theory of the Climatron is to study the effect of climate on plant growth and at present much experimentation is going on with American corn. This is a quick survey of a fascinating and thrilling creation, one could spend days wandering from climate to climate studying all sorts of strange plant growth and the display of orchids alone is worth the trek to that charming city.

Marion W. Rivinus

# Arboretum Activities

*(Continued from Page 30)*

Through the will of the late Mrs. W. Keating Johnson, long an Associate of the Arboretum, the Library acquired the back files of several important horticultural journals and a number of rare books. Among the latter were Tripp's "British Mosses" and a beautifully bound edition of Sullivant's "Icones Muscorum."

The second and larger collection was donated by Mrs. Philip P. Calvert of Cheyney, Pa. This consists of some 40 volumes and a number of sets of garden journals. Among the books are such interesting items as: "Aristocrats of the Garden" and "Plant Hunting" by E. H. Wilson, "Cultivated Evergreens" by L. H. Bailey, "Systematic Botany" by E. Warming, and Goebel's famous "Classification and Morphology of Plants."

Mrs. Calvert also presented us with two volumes of Photographs of Costa Rican Plants taken in that country in 1909 when she and her distinguished husband, who is Professor Emeritus of Zoology at the University of Pennsylvania, were writing their "Year of Costa Rican Natural History."

## The Summer Course

For the seventh year in succession, the Director, aided by members of the Staff, offered a six-weeks' Summer Course on "Woody Plants." This course, conducted under the auspices of the Summer School of the University of Pennsylvania, was made up largely of high school teachers of science who were attending as participants of the National Science Foundation's Summer Institute. Also enrolled in the class were four graduate students of the University's Division of Landscape Architecture.

As in past years, the members of the class learned to identify, through laboratory and field studies, several hundred species of trees, shrubs and woody vines. Daily walks were taken around the Arboretum and visits were made to surrounding areas, including an all-day trip to the Pine Barrens of New Jersey. In addition to the regular lectures, specialized talks and demonstrations stressed the recognition and control of plant diseases and methods of plant propagation.

Some verses composed by a member of the class, who wishes to remain anonymous, seem to us to reflect so well the spirit of the course that, with his permission, they are reproduced here.

Here's to Doctor John M. Fogg, he who loves the Jersey bog
Quite as much as Arboretum's grassy slopes;
He has done his best to reach us — tried in vain at times to teach us
Always shoring up our oft'down-hearted hopes.

He has shown us *Rhus* and *Quercus* — they were quite enough to jerk us
From our self-complacent, lazy mental state.
Still we wondered — is it *Pinus?* Is the species *saccharinus?*
What will make a lusty *Ilex* want to mate?

Daily our poor mem'ries fail us — is it *occ* — or *orientalis?*
What about the somewhat hairy lower leaf?
Are they alternate and compound? Is the bud in sight or unfound?
Are those branched or unbranched spines? They brought us grief.

We have sniffed at *Phellodendron,* looked at old *Sequoiadendron,*
And enjoyed pronouncing *Liquidambar's* name.
We have stretched the leaves of *Cornus,* but you quite forgot to warn us
That your bees are miles away from being tame.

These were six good weeks — we liked 'em, as those many miles we hiked 'em
Over Morris Arboretum in the sun.
Here's a hope that you'll remember each and every doughty member
Of your Woody Plants of Nineteen Sixty-One.

## Contributor's Fund

Several years ago there was established a Contributor's Fund to be used at the discretion of the Director of the Arboretum. Donations are tax exempt and those who contribute to this fund will enjoy the satisfaction of knowing their gifts will aid in the realization of some worthwhile project which could not otherwise be undertaken.

J. M. F., Jr.

# New Associates

The Arboretum is happy to welcome the following new Associates who have been enrolled since June, 1961:

Sister Barbara Ann, O.S.F.
Mrs. Thomas H. Atherton
Mr. Robert J. Bell
Mrs. Helen M. Bogges
Mrs. Richard Brister
Mrs. C. Clausing
Mr. and Mrs. Richard Critz
Mrs. Clifford C. David
Mrs. Edward M. David
Mrs. Kenneth M. Eden
Mrs. George Eisenman
Mrs. Alice D. Gilliland
Mr. James P. Gilliland
Miss Mary E. Gindhart
Mr. and Mrs. M. H. Goldstein
Mrs. Kenneth Hassrick
Mrs. D. P. Hatch
Hill Hardware Company
Dr. Calvin F. Kay
Mr. Richard M. Lathrop
Mrs. Balduin Lucke
Mr. Edward Martin
Mrs. Jane E. Michie
Mr. Walter E. Miller
Mrs. Simon S. Nathan
Mr. George W. Purvis, Jr.
Dr. Elizabeth K. Rose
Mrs. Mary Lu Ross
Mr. C. Richard Snyder
Mrs. Paul W. Sutro
Mr. W. Welty
Mrs. Ernest Trachtenberg